PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 2002.002	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US03/29945	International filing date *(day/month/year)* 23 September 2003 (23.09.2003)	Priority date *(day/month/year)* 19 December 2002 (19.12.2002)
International Patent Classification (IPC) or national classification and IPC IPC(7): B01D 53/22,69/04 and US Cl.: 96/8,10; 210/321.8,321.89		
Applicant EXXONMOBIL UPSTREAM RESEARCH COMPANY		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 6 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of report with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09 June 2004 (09.06.2004)	22 September 2004 (22.09.2004)
Name and mailing address of the IPEA/US Mail Stop PCT, Attn: IPEA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703) 305-3230	Authorized officer Robert H. Spitzer Telephone No. (571) 272-0987 DEBORAH A. THOMAS PARALEGAL SPECIALIST ~~GROUP 1300~~

Form PCT/IPEA/409 (cover sheet)(July 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US03/29945

I. Basis of the report

1. With regard to the elements of the international application:*

☐ the international application as originally filed.

☒ the description:
pages 1,3-7,9-11 as originally filed
pages NONE, filed with the demand
pages 2 and 8, filed with the letter of 01 September 2004 (01.09.2004)

☒ the claims:
pages 15, as originally filed
pages NONE, as amended (together with any statement) under Article 19
pages NONE, filed with the demand
pages 12-14, filed with the letter of 01 September 2004 (01.09.2004)

☒ the drawings:
pages 1-2, as originally filed
pages NONE, filed with the demand
pages 3, filed with the letter of 01 September 2004 (01.09.2004).

☐ the sequence listing part of the description:
pages NONE, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of _____.

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination(under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages NONE

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ NONE

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

*** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims 1-17	YES
	Claims NONE	NO
Inventive Step (IS)	Claims 1-17	YES
	Claims NONE	NO
Industrial Applicability (IA)	Claims 1-17	YES
	Claims NONE	NO

2. CITATIONS AND EXPLANATIONS

Claims 1-17 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry for the membrane separation of a fluid stream.

Claims 1-17 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest a membrane module for separating a multi-component fluid stream, wherein the module has a hollow shell filled with a plurality of separation assemblies that each comprise a plurality of elongated membrane elements, one end of the membrane elements of each separation assembly being attached to and hermetically sealed to an inlet manifold and the opposing end of the membrane elements being attached to and hermetically sealed to an outlet manifold, at least one of the manifolds being unrestrained, thereby permitting axial movement of each membrane element in response to temperature changes, with at least one manifold from each separation assembly being in fluid communication with a manifold from one other separation assembly.

desired product is the retentate stream, and the permeate stream comprises contaminants such CO_2 or other acid gases.

[0005] Most prior art membrane modules include: 1) individual hollow fibers or membrane tubes, or bundles of fibers or membrane tubes, 2) membrane tubesheets in the form of solid bodies of suitable material for potting the opposite ends of the membrane tubes such that their internal bores, or lumens, communicate through the membrane tubesheets, 3) a pressure container formed by an elongated pressure vessel, and 4) a pair of opposite end heads or caps closing the opposite ends of the pressure vessel. The pressure vessel thus contains, protects, and supports the tubular membranes. The opposite membrane tubesheets with the membrane tubes extending therebetween are supported and sealed within the pressure container and interior manifolds or chambers are formed between the outer faces of the membrane tubesheets and the vessel's end caps through which communication is established between end cap ports and the lumens of the membrane tubes which open at the outer faces of the membrane tubesheets. The tubular membranes are typically made from polymeric materials and the pressure vessel is typically made from either polymeric materials (for low-pressure applications) or steel (for high-pressure applications).

[0006] One disadvantage of such prior art modules is that the tubesheet thickness and weight increase significantly as the pressure rating and/or module diameter increase. Because of this, in some applications the tubesheet can become very thick, thereby significantly reducing the module packing density and increasing the weight beyond practical limits. When attempts are made to produce a large-diameter module, the large amount of membrane tubesheet material that must be positioned around the ends of the membrane tubes can present handling problems in positioning the membrane tubesheet around the ends of the membrane tubes. During operations in which wide variations in temperature occur, the membrane tubes and the membrane tubesheets can expand and contract which can compromise the integrity of the seal between the membrane tubesheets and the housing container.

[0007] Although most prior art membranes are based on relatively flexible polymer materials, a new generation of high-performance membranes is being developed based on relatively rigid, inorganic materials, such as micro-porous

seals and support are designed to withstand pressure differentials between the feed and permeate sides. The ends of the membrane tubes 13 are hermetically sealed to manifold conduits 16 and 17 in a manner which forces all of the permeate fluid exiting the membrane tubes to flow into at least one of the manifolds. This may be accomplished in any suitable fashion that prevents leaks from forming around the outer diameter of the membrane tubes 13 and the manifold 16 and 17. For example, the membrane tubes 13 may be inserted a preselected distance into or completely through the wall of the manifolds with a sealed joint being formed between the membrane tubes 13 and the manifolds 16 and 17 by welding, soldering, brazing, bonding; heating the manifolds and shrink cooling over the membrane tubes 13; threading the end of the membrane tubes 13 into the manifolds 16 and 17; sealing with nut and gasket; or using a compression fitting.

[0025] Manifold conduits 16 and 17 are in fluid communication with each other by elbow conduits 18. The use of elbow conduits 18 to interconnect the membrane units allows flexibility in the design of the fluid flow path within the membrane units 12. For example, membrane units 12 can be interconnected for either series or parallel flow paths. In some cases, it may be desirable to plug one end of a manifold conduit 16 or 17 to direct flow through the membrane tubes 13 rather than to a manifold conduit from another membrane unit 12. The use of elbow conduits 18 to interconnect membrane units 12 can result in an overall structure that is relatively spring-like and therefore able to withstand strain due to thermal expansion more readily than if rigid headers were used. Also, the elbow conduits can allow for variations in the length of the manifold conduits 16 and 17 from one membrane unit 12 to the next. In this manner, the membrane units can be graduated in width to efficiently fill a cylindrical shell 11. Depending upon the method used to join the manifold conduits 16 and 17 to the elbow conduits 18, it may be possible to remove individual membrane units 12 from the module assembly for testing or service.

[0026] The manifold conduits 16 and 17 are also in fluid communication with at least one external port 22 opening to the exterior of shell 11, thereby providing at least one flow passage of permeate with the one external port 22. As illustrated in Figs. 1, 3 and 5, the membrane units preferably are also in fluid communication with an inlet

What is claimed is:

1. A module for separating a multi-component fluid comprising:

a hollow shell having a hermetic enclosure;

a plurality of separation assemblies in side by side relationship disposed in the shell;

each separation assembly comprising a plurality of elongated membrane elements, at least a portion of each membrane element comprising a semipermeable surface to permit selective permeation of one or more components of the multi-component gas into the membrane element;

one end of the membrane elements in a separation assembly being attached to and hermetically sealed to an inlet manifold and the opposing end being attached to and hermetically sealed to an outlet manifold, at least one of the manifolds being unrestrained, thereby permitting axial movement of each membrane element in response to temperature changes;

the shell having at least one inlet conduit for introducing the multi-component fluid into the shell for treatment at a first pressure and at least one exit conduit for passage of treated multi-component fluid out of the shell;

at least one manifold from each separation assembly being in fluid communication with a manifold from one other separation assembly, the plurality of separation assemblies being in fluid communication with each other; and

at least one exit conduit for passage of permeate at a second pressure being lower than the first pressure from one of the manifolds out of the shell.

2. The module of claim 1 wherein the shell is generally cylindrical having an axial length.

3. The module of claim 2 wherein the plurality of membrane elements are membrane tubes that are substantially parallel to the axial length of the shell.

4. The module of claim 1 further comprising an additional conduit for passage of sweep gas from outside the shell into one of the manifolds.

5. The module of claim 1 wherein the separation assemblies are stacked in a disk-like configuration.

6. The module of claim 5 further comprising an additional conduit for passage of sweep gas from the outside the shell into one of the manifolds.

7. The module of claim 1 wherein a sealing material that is substantially leakproof to multi-component gas at least partly occupies the space between the exit conduit of the permeate and the shell.

8. The module of claim 1 further comprising spacer members between and spacing each adjacent separation assembly.

9. The module of claim 1 wherein the membrane element comprises a semipermeable membrane layer formed on a microporous support tube.

10. The module of claim 9 wherein the membrane layer is formed from a porous silica.

11. The module of claim 9 wherein the membrane layer has a pore size ranging from about 0.1 Å to about 10 Å.

12. The module of claim 1 wherein a plurality of baffles are disposed substantially perpendicular to at least one of the membrane elements and are effective to distribute multi-component fluid across the outer surface of the membrane elements.

13. The module of claim 2 wherein the cylindrical shell has oblate ends.

14. The module of claim 1 wherein the first pressure is above 1,200 psia.

15. The module of claim 1 wherein at least a portion of the shell is made of a first material and at least a portion of each membrane element is made of a second material, the first and second materials having different coefficients of thermal expansion.

16. The module of claim 9 wherein the membrane layer is formed from a zeolite.

17. A module for separating a multi-component fluid comprising:

a chamber-defining, cylindrical shell having oblate end sections formed integrally with the cylindrical portion, at least a portion of the shell being formed of a first material;

a plurality of stacked separation assemblies in side by side relationship disposed in the shell;

each separation assembly comprising a plurality of elongated, substantially parallel, membrane elements, at least a portion of each membrane element comprising a wall being adapted to separate the multi-component fluid into permeate and retentate streams, at least a portion of the membrane being formed of a second material, said first and second materials having different coefficients of thermal expansion;

one end of each membrane element being attached to and hermetically sealed to a first manifold and the opposing end of each membrane element being attached to and hermetically sealed to a second manifold, one or both the first and second manifolds being unrestrained in the axial direction of the shell;

the shell having a first inlet conduit for introducing the multi-component gas into the shell for treatment at a first pressure and a first exit conduit for passage of treated multi-component gas out of the shell;

the first manifold of one separation assembly being in fluid communication with the first manifold of an adjacent separation assembly and the second manifold of one separation assembly being in fluid communication with

the second manifold of and adjacent separation assembly, whereby the plurality of separation assemblies are in fluid communication with each other; and

the shell having a second inlet conduit for introducing a sweep gas into the second manifold and a second outlet for passage of permeate from the first manifold out of the shell.

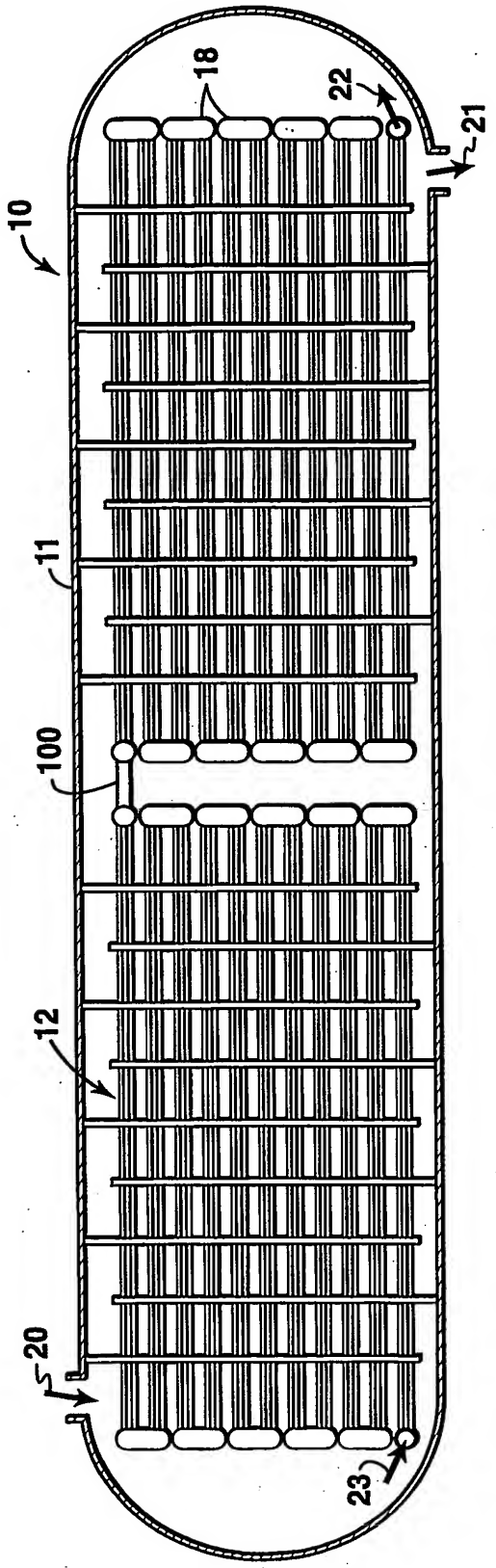

FIG. 5